Safety Considerations for Electric Vehicles

What Safety Professionals, Electric Vehicle (EV) Drivers, Emergency Responders, EV Maintenance Personnel, and Other Affected People Need to Know

**IMPORTANT USER NOTE: This document was created in 2014 by the DoD Electrical Safety Working Group (ESWG) and is based on Codes and Standards in force in 2014. To use this document properly, the user must refer to the code in force at the date of use.*

DoD Vehicle-To-Grid (V2G) Pilot Program

Objective is to replace general purpose fleet vehicles with plug-in electric vehicles (PEVs), including fully-electric, plug-in hybrid electric, and extended-range electric vehicles. The PEVs will be power grid-integrated to generate value through grid ancillary services, such as frequency regulation and peak shaving.

Project Scope

- Initiate large-scale testing and evaluation program for PEVs on 6 installations (DOD-wide) in four regions, with the following features:
  - 100-500 PEVs with V2G capability
    - LD pick-up trucks
    - LD cargo/passenger vans MD/HD trucks
    - and vans Buses
  - One V2G-capable charging station per PEV
  - Specialized software to manage PEV fleet with V2G capability
  - Training for multiple DOD constituencies
  - Sustainment for PEVs, infrastructure, and software
  - Program management and systems integration
- Demonstrate financial and operational benefits of a V2G fleet
- Option to expand up to 1,500 PEVs on up to 30 installations

DoD Vehicle-To-Grid (V2G) Pilot Program and Southern California Edison

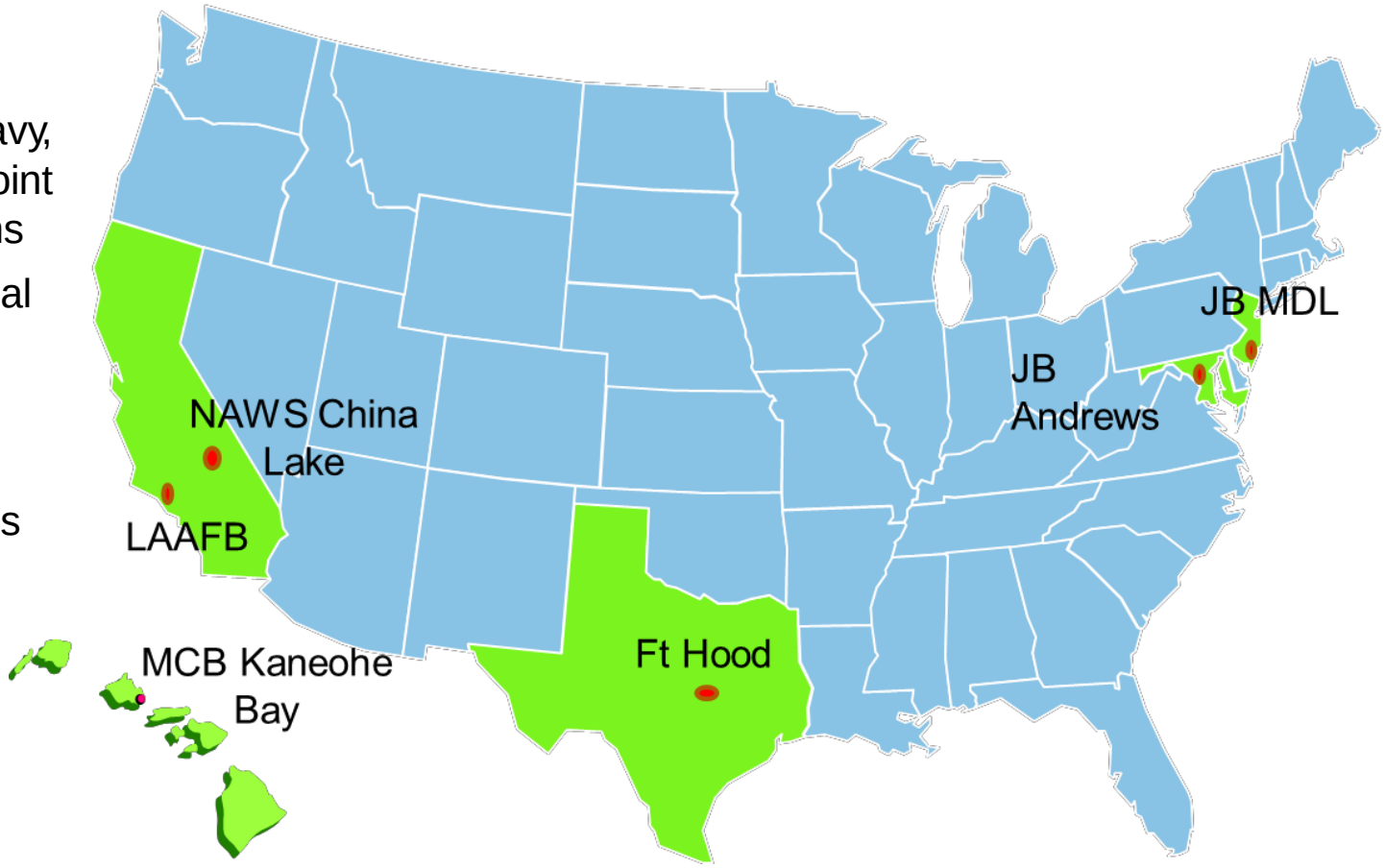
Southern Cal Edison is working with the DoD to perform V2G testing and safety evaluations on plug in electric vehicles and chargers before deployment to identified bases.

Items in review will include but are not limited to…

- Vehicle and Charger Performance
- Battery
- Range
- Energy consumption
- Ground fault
- Temperature
- Drive away protection (vehicle disable)
- Grid events

PEV–V2G Pilot Locations

- USAF, Army, Navy, Marines, and Joint Base installations
- Different electrical grid territories
- Different base sizes
- Different climates
- Different vehicle requirements



Plug In Electric Vehicle (PEV), Plug In Hybrid Electric Vehicle (PHEV) and Internal Combustion Engine (ICE)

A PEV is a vehicle powered by an electric battery, which is plugged into a charging station or wall socket.

PHEV is vehicle with an internal combustion engine (ICE) with an electric motor which is plugged into a charging station or wall socket.

The DoD V2G Project is focused on battery powered plug in electric vehicles.

Medium- and Heavy-Duty Trucks - Examples

About PEVs and PHEVs

Dependability and Limitations
Charging the Vehicle
Battery Packs
Maintenance
Towing

About the Vehicle…

- Dependability of a PEV
  - They're just as dependable as gas-powered vehicles. Electric motors have fewer moving parts therefore, fewer points of failure. Charge it up and go!

- Limitations: Range
  - Limited charging stations
  - Time to charge
  - Vehicle type…Car vs. truck
  - Battery type…Lithium-Ion
  - Added weight…None vs. freight/materials
  - State of charge…Full-charge vs. half-charge
  - Environment…Flat terrain vs. hills and inclines
  - Driver…Mindful of how the vehicle operations

In Addition: PEVs and PHEVs are showing up in Forbes reports, Kelly Blue Book and the NHTSA reports with top ratings for safety and dependability.

About the Vehicle Continued…

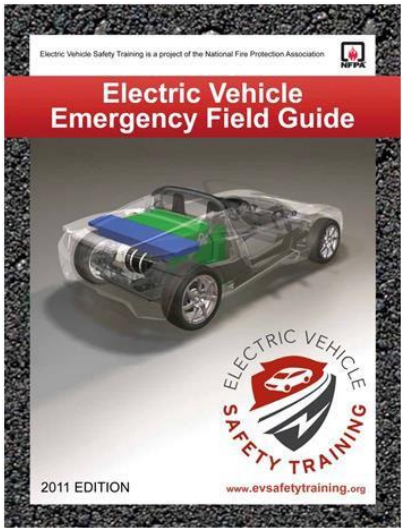
- Charging the vehicle
  - Just plug it in!
  - Each base has a designated charging site.
  - The charging system will have a *V2G* software management system for grid, charger and vehicle reporting.
  - Vehicle may be equipped with a portable charger.
  - PEVs require a period of time for charging. It depends on the charger type i.e., commercial vs. portable and state of charge.
  - Charge will auto cut off when either disconnected, timer set is complete or when the state of charge is complete
  - Pack is in a protected casing and can with stand various terrain conditions. So don't worry about the pot holes and water submersion.

About the vehicle continued…

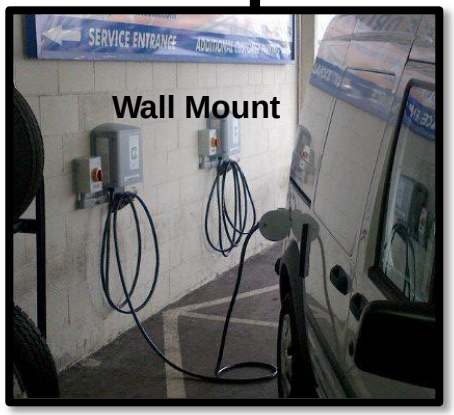
- Maintenance
  - Routine tire rotation, windshield wiper and brake fluid fills.
  - Software upgrades are maintained by the mfr unless otherwise instructed and other personnel are approved and have been trained by the mfr.
  - No longer needed!!
    - Oil changes
    - Belt replacements
    - Various “engine” repairs
    - Fewer brake changes due to regenerative braking system
    - Coolants, fuel filters, etc. etc

- Emergency Responders (NFPA Training is Recommended)
  - See NFPA’s Emergency Field Guide

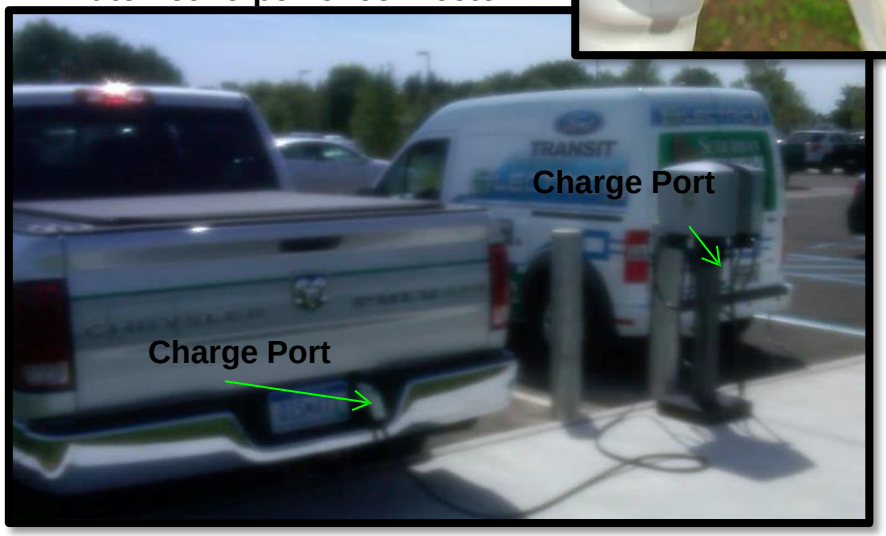
- Tow Operators
  - Follow manufacturer guidelines for proper towing. Flat tow automatic or manual is typically required to not damage the vehicle or battery pack and tow dollies are typically never allowed.
  - BE AWARE…. Electric vehicles are very quiet! Be conscious as a driver and as a pedestrian.



Industrial Charging Systems - Examples



SAE J1772-2009 electric vehicle connector.
Type
Automotive power connector



Pedestal

Safety Poles

Industrial Charging Systems – Installed at LAAFB

UL
Hanging cords
Safety poles

Electric Vehicle Safety

EV Design Safety Features
(Crash Worthiness, High Voltage Cables, Battery Packs and Fires)

EV Charger Safety Features
(Weather, Damaged, Power Surge, and Fires)

Driver and Fleet Maintenance

Tow Operators and Emergency Responders

EV Design Safety Features
(Crash Worthiness, High Voltage Cables, Battery Packs and Fires)

- Electric Vehicles are built to meet all NHTSA (FMVSS) requirements and have certified crash testing rating.

- ALL high-voltage cables are identified in a protective **orange** casing and meet SAE Standards. There is virtually no way for an individual to come in contact with these cables unless improperly cutting the cables.

- Battery packs are comprised of multiple compartments and are encased in a protective structure for pack protection from environmental leaks, individual safety and driving conditions and various road hazards. Pack "kill switches" are installed on the vehicle. The packs have also been tested and meet SAE standards.

- Fires are highly unlikely. There are no fuels in a PEV, other than brake fluid and windshield wiper fluid. Remember no engine.

Note: PEVs and PHEVs may vary in battery type, kill switch location and they # they have. READ the vehicle manual for the vehicle you are in contact with, NEVER make the assumption they are all "exactly" the same.

Battery Pack Safety

- High-voltage and low-voltage lines are separated for electrical safety and are identified in **orange**.
- Built to attain complete electrical isolation of the battery pack from the vehicle. An HVIL (High Voltage Interlock System) is used to prevent exposure of occupants to high voltages
- BMS (battery management system) carries out critical safety functions such as charging and health management
  - Opens the contactors when voltage, current and temperature limits critical from safety points of view are violated.

Protective Pack Casing

Modules Located In The Pack

Be sure to review the Vehicle Battery Materials Safety Data Sheet (MSDS) for chemical makeup and precautions

EV Charger Safety Features

Electric Vehicle Standardization efforts cover all aspects of the charger infrastructure, battery, vehicle, safety, testing, validation, manufacturing, service, recovery and recycling.

- Outdoor rated and is safe to charge in the rain
- Ground fault protection
- Safety features are in place for the charger breakers to trip if the charger is compromised i.e., hit by the vehicle or vandalism
- Surge Protection
- Vehicle Battery Management System (BMS), no over charging/heating of the pack
- Manual Emergency Main On/OFF power switch

“Kill Switch Identification, Location & Access

One Kill Switch is located at the back of the console and requires a tool to remove a bolt for access.

1 Main kill switch is located on the console for easy access to the driver. There are also two manual kill switches located on both sides of the truck behind the cab. **3** Total Switches

Driver and Fleet Maintenance

Drivers

- Approved by DoD
- Follow DoD vehicle usage policy and procedures
- Review vehicle manual for PEV specifics
- Know what type of battery pack the vehicle uses
- Identify all vehicle “kill switches”
- Do NOT tamper with voltage cables. **Electrocution** is possible if the vehicle is powered on.

Fleet Maintenance Personal

- Approved by DoD and trained by the manufacturer for services or repairs performed on a PEV.
- Do Not work on a PEV or HEV without approval and training.
- Virtually no maintenance outside of tire rotation and balancing
- **Electrocution** is possible if manufacturer procedures are not followed.

Tow Operators

NHTSA
US Department of Transportation Interim Guide

Interim Guidance for Electric and Hybrid-Electric Vehicles Equipped With High Voltage Batteries

(Towing and Recovery Operators and Vehicle Storage Facilities)

Electric and Hybrid-Electric Vehicle Considerations

In the event of damage or fire involving an electric vehicle (EV) or hybrid-electric vehicle (HEV):

- Always assume the high voltage (HV) battery and associated components are energized and fully charged.
- Exposed electrical components, wires, and HV batteries present potential HV shock hazards.
- Venting/off-gassing HV battery vapors are potentially toxic and flammable.
- Physical damage to the vehicle or HV battery may result in immediate or delayed release of toxic and/or flammable gases and fire.

Vehicle Shutdown and High Voltage System Disabling

IDENTIFY VEHICLE

- Determine if the vehicle is an electric or hybrid-electric vehicle, and if it is, advise your Dispatch and all other responders that an electric or hybrid-electric vehicle is involved.
- If you detect leaking fluids, sparks, smoke, flames, increased temperature, gurgling, popping or hissing noises from the HV battery compartment, ventilate the passenger area (i.e., roll down windows or open doors) and call 911.
- Be alert. There is a potential for delayed fire with damaged lithium-ion batteries.

RECOVERING/TRANSPORTING VEHICLE

- **Call an authorized service center or vehicle manufacturer representative, if necessary, to determine additional steps that you should take to safely recover or transport the vehicle.**
- Always approach vehicle from the sides to stay out of potential travel path. It may be difficult to determine if the vehicle is running due to lack of engine noise.
- Place vehicle into Park, set the parking brake, turn off the vehicle, activate hazard lights, and remove keys to a distance at least 16 feet from the vehicle until loading the vehicle for transport.
- Refer to vehicle manual/recovery guide to locate proper attachment/connection points and transport method.
- Avoid contact with orange high voltage cabling and areas identified as high voltage risk by warning labels.

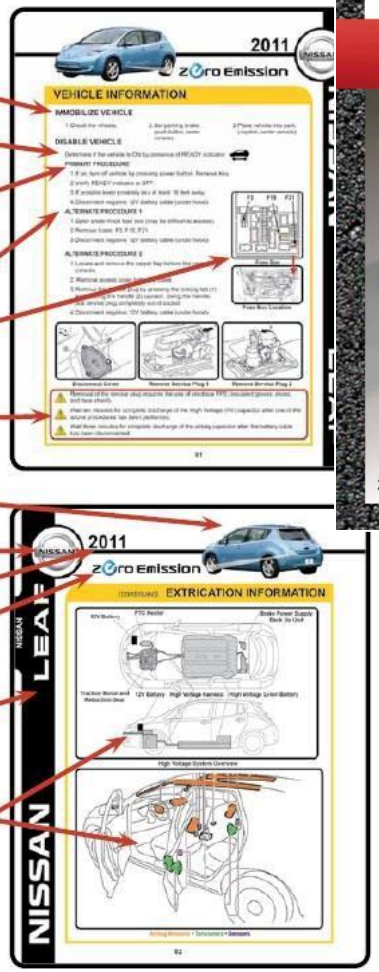
STORING VEHICLE

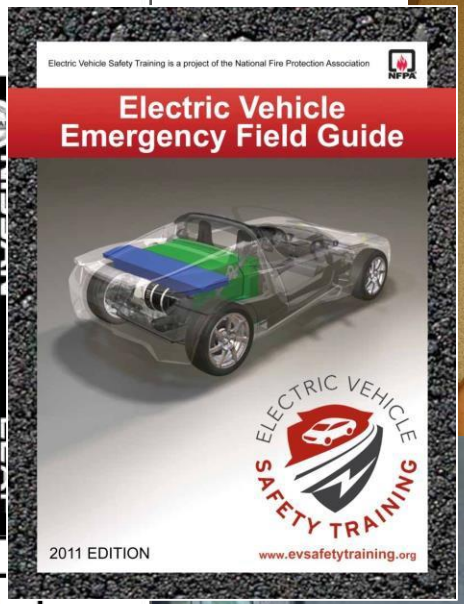
- **Notify an authorized service center or vehicle manufacturer representative as soon as possible as there may be additional steps necessary you or they can take to secure and, discharge, handle, and store the HV battery and vehicle.**
- Do not store a severely damaged vehicle with a lithium-ion battery inside a structure or within 50 feet of any structure or vehicle.
- Ensure that passenger and cargo compartments remain ventilated.
- Prior to placing and while located in storage area/tow lot, continue to inspect vehicle for leaking fluids, sparks, smoke, flames, gurgling or bubbling sounds from the HV battery and call 911 if any of these are detected.
- Maintain clear access to stored vehicles for monitoring and emergency response if needed.

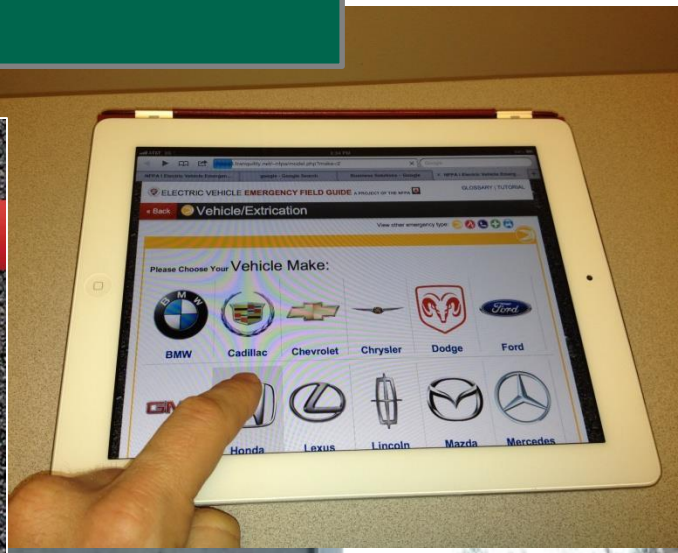
NFPA's Emergency Field Guide

HOW TO USE THIS GUIDE

- Immobilization
- How to Determine if Vehicle is ON / OFF
- Primary Disabling Procedure
- Alternate Disabling Procedures
- Disabling Procedure Supporting Diagrams
- WARNINGS
- Vehicle Photo
- Manufacturer Badge
- Model Year Range
- Vehicle Badging
- Make and Model Tab
- System Diagrams (High Voltage, Airbags, SRS—if Available)







In the news:

Expensive Tesla Electric Vehicle Crashes in Murfreesboro, Driver Charged with DUI

The vehicle in this crash was probably the only one of its kind in Murfreesboro and possibly in the state. It was a current 2012 Tesla Model S, all electric vehicle. The young female driver possibly survived because this car has a 5-star safety rating for front, side or rollover crashes. In checking the Tesla website, they note the high-strength steel and aluminum frame contribute to its crash performance. It appeared that possibly all 8 airbags had opened, plus this is not a lightweight car--it weighs a little less than 5,000 pounds.

Before police could release the electric vehicle to be loaded onto the flatbed wrecker, they had to secure information on how to turn off the Tesla Model S. Officials received technical instructions, and the all electric 4-door car was shut down.

Accident Investigation

PEV and PHEV

- Always assume the high voltage battery and associated components are energized and fully charged.
- Exposed electrical components, wires, and batteries present potential shock hazards.
- Venting/off-gassing battery vapors are potentially toxic and flammable.
- Physical damage to the vehicle or battery may result in immediate or delayed release of toxic and/or flammable gases and fire.

EMERGENCIES

CRASH: A crash or impact significant enough to require an emergency response for conventional vehicles would also require the same response for electric or hybrid-electric vehicles.

<u>If possible</u>

- Move your car to a safe, nearby location and remain on the scene.
- Roll down windows before shutting the vehicle off.
- Place the vehicle in Park, set the parking brake, turn off the vehicle, activate hazard lights, and move keys at least 16 feet away from the vehicle.

<u>Always</u>

- Call 911 if assistance is needed and advise that an electric or hybrid-electric vehicle is involved.
- Do not touch exposed electrical components or the engine compartment, as a shock hazard may exist.
- Avoid contact with leaking fluids and gases, and remain out of the way of oncoming traffic until emergency responders arrive.
- When emergency responders arrive, tell them that the vehicle involved is an EV or HEV.

FIRE:

- As with any vehicle, call 911 immediately if you see sparks, smoke, or flames coming from the vehicle.
- Exit the vehicle immediately.
- Advise 911 that an electric or hybrid-electric vehicle is involved.
- As with any vehicle fire, do not inhale smoke, vapors, or gas from the vehicle, as they may be hazardous.
- Remain a safe distance upwind and uphill from the vehicle fire.
- Stay out of the roadway and stay out of the way of any oncoming traffic while awaiting the arrival of emergency responders.

Accident Investigation Cont'd

POST-INCIDENT

- Do not store a severely damaged vehicle with a lithium-ion battery inside a structure or within 50 feet of any structure or vehicle.
- Ensure that passenger and cargo compartment remain ventilated, i.e., open a window, door or trunk.
- Notify an authorized service center or vehicle manufacturer representative as soon as possible as there may be other steps they can take to secure and discharge the PHV battery.
- Call 911 if you observe leaking fluids, sparks, smoke, flames, or hear gurgling or bubbling from the PHV battery.

VEHICLE INFORMATION

- Know the make and model of your vehicle.
- Review the owner's manual and become familiar with your vehicle's safety information and recommended safety practices.
- Do not attempt to repair damaged electric or plug in hybrid-electric vehicles yourself. Contact an authorized service center or vehicle manufacturer representative for service.

Resources

- The National Highway Traffic Safety Administration is dedicated to achieving the highest standards of excellence in motor vehicle and highway safety. NHTSA provides the public with facts on vehicle safety, driving safety, and research. (www.nhtsa.gov) (www.safecar.gov) (www.ems.gov)

- Electric Vehicle Safety Training is a nationwide program through the National Fire Protection Association to help firefighters and other first responders effectively deal with emergency situations involving electric and hybrid-electric vehicles. The Web site hosts an EV blog, calendar of events, training videos, emergency field guides from 19 auto manufacturers, research reports, as well as an online training course for the Chevy Volt. (www.evsafetytraining.org)

- SAE International is a resource for vehicle safety codes and standards. It has recently developed and revised safety standards for electric vehicles. (www.sae.org/standards)

- The Electric Drive Transportation Association is a resource for learning about different types of hybrid-electric and electric vehicles. It also has a fact sheet that details the numbers of hybrid vehicles on the road now and how many we can expect in the future. (www.electricdrive.org)

- The Alternative Fuels and Advanced Vehicles Data Center provides information, data, and tools to help fleets and other transportation decision-makers find ways to reduce petroleum consumption through the use of alternative and renewable fuels, advanced vehicles, and other fuel-saving measures. (www.afdc.energy.gov/afdc)

- HybridCars has detailed resources on every hybrid model on the road today. Its research section also provides studies and surveys about hybrid and electric vehicles in relation to technology, the environment, culture, and law. (www.hybridcars.com)

- The National Alternative Fuels Training Consortium promotes programs and activities that lead to energy independence, and encourages the greater use of cleaner transportation. (www.naftc.wvu.edu)